Measurement of general etch rate for CR-39 plastic at short distance scale*

Y. D. He, C. I. Hancox†*, and M. Solarz*†

In this paper we demonstrate that submicron changes in the thickness of solid state nuclear track detectors during chemical etching are measurable with a laser interferometer. Such real-time monitoring allows us to determine with good accuracy the general etch rate of the detectors at very short distance scale. Combined with track measurements from an atomic force microscope, it is possible to study the detector response in this previously unexplored regime. We report a set of measurements for CR-39 plastic detectors obtained with this technique.

Traditionally, tracks in a detector plate are etched to tens of microns so that they become suitable for optical measurements either semi-automatically or automatically [1, 2]. Values of G, typically in the range of 10–100 μm, are determined directly with a micrometer or indirectly from the measurement of weight loss before and after each etch sequence of duration t. The measurement accuracy is on the order of 1 μm, leading to an error $\geq$ 10% for $G \leq 10$ μm. Since v_{G} is calculated from G and t, the determination of v_{G} can not be made accurately for small distance scales $G \leq 10$ μm. Recently, the use of an atomic-force-microscope has made it possible to measure tracks of substantially smaller size at an exceedingly high track density for BP-1 glass [3] and for CR-39 plastics [4]. The measurement of the general etch rate at a scale as short as tens of nm becomes crucial in determining the detector response in this previously unexplored domain. Since this cannot be done by the weight loss method with required accuracy, a new technique had to be devised.

A home-made laser interferometer was used to monitor the real-time change in the thickness of the CR-39 plastic as it etched. The apparatus consisted of a He-Ne laser, a photodiode, an optical lens, a reflection mirror, an A-D converter, an etchant container, and a teflon stage. A sample of CR-39 plate was installed on the teflon stage and immersed in the NaOH etchant in the inner container. An interference pattern produced by the phase difference ϕ between the beams reflected off the front and back surfaces was optimized by making optical adjustment. The photodiode was used to measure the intensity of the fringe pattern. We obtained the general etch rate from the power spectrum for each set of time-series data. No short-term variation of general etch rates was found within an accuracy of 5 nm hr^{-1} beyond the shortest measurable distance of $\sim$ 50 nm.

Among CR-39 users, it has been known for a long time from laboratory experience that a 20 degree change in temperature corresponds approximately to a change of a factor of five in general etch rate. Our present work shows that this dependence is also valid in a range down to submicrons. The best fit to the data is $v_{\mathrm{G}} = \alpha \exp(\gamma T)$, where $\alpha = 4.24$, $\gamma = 0.0802$, with temperature T in °C.

References

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†Physics Department, University of California, Berkeley, CA 94720.